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NOTE ON THE PHYSICAL WORLD-ORDER. II

HAVING defined a *physical science* as *one which employs in its description of nature only such terms as can adequately be defined by the use of the measuring rod,* it was shown in what sense sciences recognized as physical fell under this definition. The question, What sciences, if any, do not fall under this definition, led to the further question, What does it mean to say that a phenomenon is enexplicable in physical terms?

By way of leading up to this special question let us ask a more general one: When is any phenomenon shown to be inexplicable in terms of any given law? That we do constantly assume phenomena to be inexplicable in terms of the given law hardly needs illustration; but to give one,—the turning of a galvanometer needle under the influence of a current is said to be inexplicable in terms of the law of gravitation. But why?

Here we must go step by step, and let us begin with a very simple case. If I dip the end of a capillary tube into a tank of water, the water will rise in the tube and remain stationary at a certain distance above the level of the water in the tank. This phenomenon is described as a case of capillary attraction, and it was once supposed that capillary attraction might be explained in terms of the law of gravitation. It is now generally admitted that no such explanation is possible. In what does the proof of this impossibility consist?

To say that the rise of water in the capillary tube can not be the result of gravitation would at first suggest nothing more than the perfectly evident reflection that the mass represented by the little column in the tube can not be repelled from the center of the earth in conformity with a law which provides for the attraction of masses. But with this obvious conclusion might come a new suggestion: if we consider the walls of glass and the column of water to be made up of molecules of glass and water respectively, could we not make such hypotheses respecting the masses and the interstitial distances of these molecules as would reveal the rise of a mass against gravity to be really a case of the same law of gravitation? The question is meaningful, and if we are at liberty to distribute the masses and the distances without further restriction than that the sum of the molecular masses should equal the gross mass, the spatial arrangement of the molecules conform with the gross dimensions of the bodies, we should, no doubt, be able to explain the phenomenon of capillarity on a gravitational basis. But the question at once arises, Are we free to distribute masses and assume distances without other restrictions than those mentioned? Such might be the case if the phenomenon of capillarity were the only one which led us to assume a molecular structure of bodies. As it is, however, the size of molecules and their distances have been fixed by observations quite independent of the phenomenon of capillary attraction, and they have been fixed in such a way that, without revolutionizing the rest of molecular physics, those particular phenomena can not be explained in terms of the law of gravitation.

This, then, is the sense in which, in the actual pursuit of science, we say that a given fact can not be explained by a given law. But it will be remarked that this demonstration is of a somewhat hesitating kind. So much depends upon our definition of the phenomenon we are called upon to explain. Define it in one way, it is inexplicable; define it in another way, it is explicable. These two or more ways of defining a phenomenon are necessarily consistent, but they are sufficiently different to make it possible to return the answer *yes* and *no* to the same question. How can we ever be sure that we have obtained a final *no* to the question: Can such and such a phenomenon be so and so explained? The most that we can say is this: the given phenomenon can not be explained by the given law, *unless* we describe the phenomenon in a way which would only be permissible in case we made changes of such and such magnitude in our accepted scientific conceptions. Nevertheless, let us take this demonstration of the inexplicability of a given phenomenon by a given law as the nearest approach we can make to absolute demonstration: let us admit that it offers all that can be demanded of such a demonstration. The question arises, Under what conditions has it a meaning to ask for such a demonstration of inexplicability?

If I mix a kilogram of water at 50° C. with a kilogram of water at 100° C. without allowing any heat to escape, the resulting mixture will have a temperature of 75° C. Can this phenomenon be explained by the law of gravitation? It seems absurd to ask such a question. We no longer seek to demonstrate the impossibility of the explanation demanded: we are satisfied with an immediate insight into the meaninglessness of the proposition. Evidently, we say, it is impossible that a phenomenon for whose description we require the term 'temperature' should be susceptible of explanation by a law in which the term 'temperature' does not even occur. Capillary phenomena may not be explicable by the law of gravitation, but they are at least describable in the dimensions of that law, to wit, the dimensions mass, length, and time. It is therefore meaningful to ask whether such phenomena be explicable in terms of this law, and we require a demonstration of the law's failure to explain before we answer in the negative. But the suggestion that a phenomenon describable in one set of dimensions should be explicable by a law applying to another set of dimensions, is one that it would occur to no one seriously to offer.

If it be meaningless to ask for a mechanical explanation of the phenomena of heat, so long as these phenomena are described in terms of temperature, there is, nevertheless, a way in which we may redescribe the phenomena of heat without making use of this non-mechanical term, and when we have so redescribed the phenomena the search for a mechanical explanation of them no longer presents an absurdity. Suppose in our example we were to describe the water of higher temperature as a body whose molecules were vibrating with a certain average velocity, and the water of lower temperature as one whose molecules were vibrating with another and lower average velocity. Now let us picture to ourselves that in the mixing of these two masses of water the redistribution of velocities takes place according to the known laws of impact of elastic bodies, giving a mean average velocity for the mixture. We should then have given a mechanical explanation of the phenomenon of mixture, having first, however, given it a mechanical description.

The moment it becomes meaningful to ask whether a phenomenon be explicable in terms of a given law, at that moment it becomes necessary to demonstrate the impossibility of such an explanation before accepting a negative answer to the question. The search for the mechanical explanation of physical phenomena is one of the significant movements of physical science, and we observe the conditions to the success of this search. They are, first, the restatement of the problem in mechanical terms; and second, the finding of a law in which these terms may be connected. We have seen (in the example of the phenomenon of capillary attraction and the law of gravitation) the sense in which a phenomenon describable in mechanical terms may be demonstrated to be inexplicable by a *given* law connecting such terms. We now ask whether any such demonstration could be given of the impossibility of the more general task of explaining a given mechanical phenomena in terms of *any* mechanical law. In the first case the demonstration was one only when we placed upon ourselves certain restrictions as to the nature of the assumptions that could be made. In the present case, too, demonstration would evidently be possible only in case we were able to find similar (though perhaps much broader) restrictions. If, for example, we were to understand by a mechanical explanation not merely one that was conceived in terms of mass, length, and time, but further one that was required to conform to particular axioms (the axioms, say, of Newton's mechanics), it is conceivable,—yes, it has even been suggested,—that certain physical phenomena could receive no mechanical explanation. But if we free ourselves from all restrictions, it follows from what has gone before that no such demonstration would be possible. It would, therefore, be meaningless to make the hypothesis that a mechanical phenomenon was inexplicable in mechanical terms. It would evidently be equally meaningless to make the no more restricted hypothesis that a given physical phenomenon, *i. e.*, a phenomenon capable of physical description, was inexplicable in physical terms.

We have now seen in what cases it is meaningful and in what cases it is meaningless to make the hypothesis that a given phenomenon is inexplicable in terms of a given law.

1. If inexplicable is to mean anything more than unexplained, we must intend the inadequacy of the type of explanation sought to be demonstrable.

2. We see that such a demonstration could have a meaning, although a relative one, in case we were required to explain a phenomenon describable in certain terms by means of a special law connecting these terms (*e. g.*, to explain capillarity by the law of gravitation).

3. Under this head would fall also the case in which we were required to explain a phenomenon describable in one set of terms by a special law connecting another set of terms, provided we were first able to redescribe the phenomenon in the terms of the law (*e. g.*, the case in which we were asked to explain the phenomenon of the heat of mixtures in terms of the law of impact of elastic bodies).

4. It is meaningless to seek for a demonstration of the inexplicability by a given law of a phenomenon described in another set of terms without first redescribing the phenomenon in the terms of the law (*e. g.*, to seek a mechanical explanation of the phenomenon of the heat of mixtures, described in terms of temperature).

5. And finally, it is meaningless to ask for a demonstration of the inexplicability of a given phenomenon in terms of a law upon which no restriction is laid (*e. g.*, the inexplicability of mechanical phenomena in terms of mechanical law, of physical phenomena in terms of physical law).

We may now apply these results to the problem of human conduct as exemplifying a phenomenon the possibility of whose physical explanation has been doubted. We asked in what sense it had a meaning to make the hypothesis that such a phenomenon was incapable of physical explanation. We have now seen that it can only have a meaning to make such an hypothesis in case it has a meaning to ask for a demonstration of the impossibility that is asserted. Now it is a matter of common experience that the conduct of a human being may be described and explained by means of certain laws,—laws, for example, in which the terms 'motive' and 'character' occur,—long before it is possible to give any physical explanation of that conduct. Has it any meaning to suggest that the conduct thus described and explained in terms of motive and character may eternally lack a physical explanation? Evidently the case is analogous to that in which we ask for a mechanical explanation of heat without first interpreting the phenomena involved in mechanical terms. The inexplicability is indeed eternal in about the same sense that the problem of finding the number of square inches in a cubic foot is eternally insoluble. But it need scarcely be said that to admit this inexplicability is not to assert that we have found a physical phenomenon which must eternally lack a physical explanation. We have found no gap in the order of the physical world.

The problem is, however, an entirely different one if we state it in the Cartesian way. For Descartes, the phenomenon to which a physical explanation was denied was already described in physical terms, say in terms of a slight displacement of the pineal gland. The hypothesis that such a physically described event should be eternally lacking a physical explanation is, as we have seen, meaningless, for the reason that it can have no meaning to ask for a demonstration of the inexplicability asserted. We may conclude, therefore, that this interesting phenomenon of human conduct offers us no illustration of a possible inadequacy of a physical explanation. It has only been supposed to do so either (1) because it was described in terms that were themselves not physical—in which case physical explanation is neither possible nor is it lacking—or (2) because, although described in physical terms, certain tacit restrictions are placed upon the nature of the physical laws which we contemplate; as when in our example of the boat we tacitly restrict the meaning of physical law in such wise as to include the mechanism of propulsion but to exclude the activity of the helmsman from its possible scope.

This somewhat lengthy analysis of a concrete example will enable us to answer the question that suggested it, to wit, What would a non-physical science mean? There seem to be sciences that formulate laws in terms that can not be defined by the use of the measuring rod. Is then the ability to explain and to predict in physical terms an essentially limited one? Or may the non-physical sciences coexist with the physical without limiting them?

In the light of our previous study I think we can see in what sense the latter may be the case. It might perfectly well be that every phenomenon that was capable of a physical description (*e. g.*, notion of every particle of matter in the universe) was also susceptible of a physical explanation, and yet that such phenomena might be so grouped in new classes as to be equally subject to non-physical description and explanation. For example, any clock or watch is a simple mechanism, every detail of whose behavior is susceptible of a physical description and explanation. Yet there is no common physical description, *i. e.*, no physical definition of a 'time-keeper,' including such heterogeneous mechanisms as a spring-watch, a pendulum clock, a water-clock, an hour-glass, a sun-dial. These are grouped together, not because of their resemblant mechanisms, but because of their common function. Only from this point of view can we speak of a 'good' or 'bad' time-keeper. Now to ask 'Why are dollar watches bad time-keepers?' is a question to which the answer, 'because of their cheap construction,' would be satisfactory. The general rule 'cheap watches are poor time-keepers' is a true law, but neither 'time-keeper,' 'poor,' nor 'cheap' is a term of a physical nature. Yet in a watch that keeps 'poor time' there is some physical condition, explicable by physical laws, which is not to be found in another resembling watch that keeps 'good time.'

Just so, to pass from our homely example to the general case, whole sciences may be constructed whose objects of study have no common physical nature, hence no common physical definition, and which formulate laws governing the (non-physical) behavior of those objects in non-physical terms. It would be none the less true that *each* object was composed of particles of matter, and that each particle was subject to physical law. For example, it is readily imaginable that all attempts to find a physico-chemical definition of living organism should fail. Is there any more reason that they should succeed than that all clocks should be susceptible of subsumption under a single mechanical definition? A living organism may be so called because of a peculiar function it fulfils, in spite of the complete heterogeneity of the physical means which are employed in the fulfilling. Should we expect, then, a science, whose object of study is the living organism, to formulate laws in physical terms? On the contrary, we should expect to find just such terms as 'habit,' 'variation from type,' 'selection,' 'struggle,' appearing in accepted explanations. But that is no reason whatever for doubting that every bit of matter that enters into a living being behaves in a way that is explicable, as it is describable, in physical terms.

To conclude then this sketch of the physical world-order and its relation to the whole of natural phenomena: The definition of physical science here offered makes it the science of space detail. The hypothesis that every phenomenon describable in physical terms is incapable of explanation in such terms is a meaningless hypothesis; but we need not conclude from this that the physical is the only science. The physical details of nature may perfectly well be grouped in classes that are incapable of physical definition; for objects thus described non-physical laws may be developed. The same object, therefore, may be capable of a double description. Any given human body, *e. g.*, is made up of particles whose only description is physical. As so described its behavior as a whole is the resultant of the behavior of its parts, and is susceptible of physical explanation. This same human body is capable of classification with other human bodies, animal bodies, organisms, etc., whose common element is not physical. As so grouped its behavior is not physically described, and so can not be physically explained. Yet this fact represents nothing indeterminate in the physical world-order.

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THE MEANING OF ANALYSIS

I SUGGEST that before we proceed to analysis in psychology we obtain a clear idea of what we mean by analysis. A definite fixing of a meaning may at first seem hampering and ideas of course run into one another, but in the long run we shall gain by a more accurate cutting of our words.

I shall consider it advantageous and not a confusion of spheres nor an unlawful transferring of analogies, if we can give definiteness by the use of visual forms. Such visualizations help us to mutual understanding more than word definitions, provided we are careful to remember that these forms are mere forms, have no control over experience and are to be used only in so far as experience fits into them.

I. THE VISUALIZATION OF DIVISION

The word analysis, as popularly used, is identical with division or separation, or in its simplest form with subtraction. Its usual visualization in this sense is a group of points or, when the points are arranged for easier manipulation, the visualization is the line divided into parts, *ac,* divided by *b* into *ab* and *bc*:

FIGURE 1.